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Assessing Gains in Efficient Production Among China's Industrial Enterprises

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China's program of gradual and partial reform has substantially improved economic performance. Despite lingering market rigidities, bargaining, patronage, soft budget constraints, and other phenomena that shield state-owned industrial enterprises from external pressure, industrial managers are economizing more on labor, capital, and materials.

This paper — a product of the Socialist Economies Reform Unit, Country Economics Department — is an output of a joint research project on “Industrial Reform and Productivity in Chinese Enterprises” (RPO 675-38), undertaken by the World Bank, Brandeis University, and the University of Pittsburgh, in collaboration with the Institute of Economics (CASS), the Economic Management Research Institute (System Reform Commission), the Rural Economic Research Center (Ministry of Agriculture) and the Institute of Quantitative and Technical Economics (CASS).

The project — which is part of a larger investigation of the relationship between industrial reform and productivity in formerly socialist economies under the direction of I. J. Singh, principal economist in the Socialist Economies Reform Unit — is supported with funds provided by the World Bank, the Henry Luce Foundation, and the National Science Foundation. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact CECSE, room N6-044, extension 37188 (March 1992, 21 pages).

A central objective of economic reform is to reduce the productive inefficiency — both technical and allocative — that arose under regimes in which markets and material incentives played a limited role. Jefferson and Xu formulate an approach for measuring gains in productive efficiency.

Applying that approach to Chinese industry, they evaluate the progress between 1980 and 1989 among China's large and medium-size state-owned enterprises in equalizing factor productivity across enterprises. In the early stages of reform, returns on factor investments varied greatly. Estimated to returns on investments in equipment in 120 state-owned steel enterprises varied from a low of 6 percent in 1985 to a high of 162 percent, for example. Total factor productivity in the most efficient mill was 37 times greater than in the least efficient mill.

The differences were partly the result of central planning — including administered

prices, restrictions on the flow of resources from low-return to high-return activities, and the lack of market discipline, which protects the least efficient enterprises from bankruptcy. One objective of economic reform is to create the conditions — the profit-seeking motive and market mechanisms — that motivate enterprises to improve efficiency and that permit the owners of individual factors to seek the highest returns.

Using panel data for 226 industrial enterprises, Jefferson and Xu report evidence that returns on investments in labor, capital, and materials became more equal between 1980 and 1989. Such a pattern of convergence can be the product of different factors, but the consistency of the pattern — even among large and medium-size enterprises at the heart of state planning — suggests that greater exposure to markets and stronger profit-seeking behavior are motivating gains in productive efficiency.

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1. Introduction

1.1 China, Eastern Europe, and the Soviet Union have all embarked on reform of their industrial systems. For the purpose of evaluating industrial economies during the transition, economists and policy-makers require a set of statistical measures and analytical methods that demonstrate the progress of transition enterprises toward mimicking the behavior and performance of profit-maximizing, market-oriented enterprises. This paper formulates and applies an approach for measuring gains in productive efficiency among socialist enterprises in transition.

1.2 Using established theory and micro-level data, the paper evaluates the progress of China's industrial enterprises toward satisfying one of the principal efficiency conditions of a competitive, market economy, namely, the equalization of marginal revenue factor products across enterprises. The approach and resulting measures are of direct use in evaluating critical issues of reform strategy, including China's strategy of evolutionary reform, which contrasts with the rapid, sweeping reforms proposed for the Soviet Union and implemented in Eastern Europe.

1.3 In his classic article, Farrell distinguishes between two measures of productive inefficiency -- technical inefficiency and price (allocative) inefficiency (Farrell, 1957). In a centrally planned economy in which decisions are made by command in the absence of price signals, we expect less productive efficiency than within an economy in which firms profit maximize and operate within competitive product and factor markets. Due to pressures to eliminate gross disparities in factor returns within a competitive economy, we would not expect large differences in levels of technical or allocative inefficiency, since inefficient enterprises would lose money and eventually disappear. Absent externalities, taxes and other factors that can drive a wedge between private and social returns, the equalization of factor returns implies the equality of marginal revenue products.

1.4 Obviously, Chinese enterprises the canonical neoclassical enterprise is not a useful characterization of China's typical state enterprise.¹ Yet, after more than a decade of reform, we expect these enterprises and the economic environment in which they operate to more closely conform to a competitive market economy than they did in the late 1970s, at the outset of the reform program. If reform has had its intended effect, we would expect gains in productive efficiency and the convergence of factor returns. This paper formulates and tests this convergence hypothesis.

1.5 During the early stages of China's economic reforms, striking differences existed in factor returns between sectors and across enterprises. One study by Jefferson, Rawski and Zheng (hereafter referred to as JRZ, forthcoming) finds that in 1980, labor's marginal revenue product within state industry was more than twice that within collective industry. Among individual enterprises within the same sectors, differences in factor returns were even more pronounced. Using a sample of 120 state-owned steel enterprises, another study estimates that in 1985 returns to equipment investment varied from a low of 6 percent to a high of 162 percent (Jefferson, 1990). Technical inefficiency was an important source of these divergent factor returns is revealed

¹ Firms in the industrial market economies also deviate from the pure neoclassical model, but for comparative purposes, the profit motive and market influences are sufficiently strong to characterize firms in industrial market economies broadly in term of the neoclassical paradigm.

by the finding of substantial differences within this sample of steel mills with measured total factor productivity (TFP) in the most efficient mill exceeding that of the least efficient mill by a factor of 37.²

1.6 The magnitude of these differences is, in part, an artifact of central planning, including administered prices, restrictions on the flow of resources from low- return to high-return activities and the lack of market discipline, which protects the least efficient enterprises from the threat of bankruptcy. Such disparate returns to similar factor inputs are costly, since, with the same quantity of inputs, the reallocation of factors from low-return activities to high-return activities can raise total output and national income. One of the objectives of the reform program is to create the conditions--the profit-seeking motive and market mechanisms--that motivate enterprises to improve overall efficiency and permit the owners of individual factors to seek the highest returns.

1.7 Using panel data for 226 industrial enterprises over the period 1980-89, this paper reports evidence that during 1980-1989 returns to labor, capital and materials became more equal among large and medium-size enterprises within China's state sector. We also find a significant convergence of technical efficiency. While such patterns of convergence can potentially arise from numerous sources, the consistency of the pattern suggests that even among large and medium-size enterprises within the core of China's system of state planning, price reform, greater market exposure and stronger profit-seeking behavior associated with the reform program are having the desired effect of motivating gains in efficient production.

2. Reform and Industrial Efficiency

2.1 In the late 1970s, with a view toward raising the overall efficiency and rate of productivity growth of its economy, the Chinese government initiated a broad set of reforms. While initially centering on agricultural reform and initiatives to open the economy to international trade and investment, important changes were also undertaken in the urban industrial sector and considerably expanded during the mid-1980s.

2.2 The impact of these reforms on state industry's overall efficiency is a matter of some debate. Studies which properly deflate inputs and outputs, however, do yield evidence of significant productivity improvement in the state sector. Among these, JRZ (forthcoming) find that during 1980-88, total factor productivity (TFP) grew at substantial rates within both the state and collective sectors. Their results, shown in Table 1, indicate that within state industry, TFP grew at an average annual rate of 2.40 percent, accounting for 28 percent of total output growth, while within collective industry productivity advanced at an annual rate of 4.63 percent, accounting for 27 percent of the growth of that sector. These rates indicate a marked acceleration in productivity growth compared with productivity change prior to the reforms.

² Once differences in scale, the age and investment structure of the capital stock, and product mix, including different pricing regimes, have been accounted for, the difference in TFP between the most and least efficient enterprises declines to a factor of eight.

Observers generally agree that except for the reconstruction period during 1949-57, industrial TFP during 1957-78 was stagnant.³

2.3 By expanding the profit motive, managerial autonomy, and market exposure, the following reforms have potentially contributed to greater industrial efficiency and productivity growth:⁴

Profit retention: Limited opportunities for profit retention were introduced in the late 1970s and early 1980s. In one sample of 20 state enterprises, the retention rate, zero during 1975-77, grew to an average rate of 13.9 percent during 1980-82. Within our sample of 226 large and medium-size state enterprises, this rate rose from 36.6 percent in 1986 to 44.2 percent in 1989.

Product markets: A key element of China's industrial reforms has been the introduction of the dual pricing system, in which enterprises sell above quota output at flexible prices while, over time, the share of within plan production declined. Enterprises that face market prices at the margin are making production decisions that are more reflective of underlying scarcities.⁵ In 1989, within our sample of 226 state enterprises, 149 enterprises sold all or a portion of their output on the market.

Labor and wage reforms: Various measures to enhance incentives and flexible labor allocation have been introduced to state industry. Among the more notable reforms have been the provision of bonuses out of retained earnings, the introduction of contract labor to replace permanent workers,⁶ and the optimal labor reorganization program which has enabled managers to reassign workers within the enterprise and encourage redundant workers to find new employment outside the enterprise.⁷ Enterprise data also show substantial increases in inter-

³ See Chen et al (1988) and Perkins (1988).

⁴ For informative discussions of China's industrial reform program, see Gene Tidrick and Jiyuan Chen, eds. China's Industrial Reform (1987) Oxford University Press; Bruce L. Reynolds, ed. Reform in China: Challenges and Choices (1987) M.E. Sharpe, Inc.; and Dwight H. Perkins, "Reforming China's Economic System," Journal of Economic Literature, 26,2 (June 1988): 601-645.

⁵ A survey of 429 state-owned industrial enterprises showed that market sales of these enterprises reached 32 percent of total sales in 1984, rising to 44 percent during the first half of 1985. See Diao (1987).

⁶ For an evaluation of the positive incentive effects of raising the share of bonuses in the total wage bill and the share of contract workers among total employees, see Groves, McMillan and Naughton, 1991.

⁷ For an analysis of the beneficial impact on labor productivity of enterprises adopting the optimal labor reorganization program, see Jefferson and Xu, 1991.

enterprise labor mobility and the autonomy of enterprises to recruit new workers.

Financial reforms: Key financial reforms include the shift away from government grants as a source of investment funds. Investment financing now comes principally from the banking system, at government-determined rates of interest, and out of retained enterprise earnings. In 1989, within our sample of 226 enterprises, while only 6 percent was financed out of central or local government budgets 53 percent was financed out of retained profits, loans from other enterprises or bond sales.⁸

Material and energy reforms: Important reforms in the materials and energy sectors include the introduction of the dual price system, allowing for greater quantities of materials to be purchased on the market. With the sample of 226 enterprises used in the present study, by 1989 only 29 percent of material inputs were obtained from plan quotas.

2.4 In the absence of specific knowledge about the impact of these reforms, we expect them to have engendered greater profit-seeking behavior and market discipline. Predicted effects should include: (i) reallocations of factors among enterprises to firms capable of generating higher returns and (ii) gains in technical efficiency as less efficient enterprises move toward the frontier isoquant of their respective industries. Together these effects should have created a tendency for factor returns to converge during the reform decade of the 1980s.

2.5 For an economy such as China's, administered prices and price reform can substantially affect the measurement of factor returns. We therefore acknowledge that, even in the absence of physical reallocations of factor inputs or changes in relative technical efficiencies, changes in relative product and input prices can affect measures of factor returns. In Section 6, we examine the impact of changing prices on measures of productive efficiency.

3. Studies of Productive Efficiency In Chinese Industry

3.1 JRZ (forthcoming) suggest that gains in allocative efficiency have been an important source of overall industrial productivity growth. Over the period 1980-88, they find a tendency

⁸ Jefferson and Xu (1991) find in their relatively small sample that enterprises with the largest shares of self-financed investment also experienced the highest rates of growth of capital productivity over the period 1984-87. They also find that during this period, within their sample and a second sample of 120 steel plants, the most profitable enterprises also enjoyed the highest rates of capacity growth, suggesting more rational patterns of investment.

toward the equalization of factor returns--those of labor, capital and materials--between state and collective industry. Jefferson and Xu (1991) investigate the convergence of factor returns among enterprises using two sets of panel data: one, consisting of 20 industrial enterprises in Wuhan City, covers the period 1978-87; the other consists of an enlarged, nationwide set of 352 enterprises for 1980 and 1987. Both sets of data reveal patterns of convergence of factor returns. In their samples, returns to capital, labor and materials are each found to converge.

3.2 Neither of these studies investigates the tendency for levels of technical efficiency to become more equal during the reform period. To investigate the issue of whether technical efficiency has become more uniform at the enterprise level, Dollar (1990) uses data collected by Tidrick and Chen (1987) for 20 industrial enterprises covering 1978-82. During these early years of the reform program, Dollar finds a tendency for TFP (labor and capital) to converge.

3.3 These findings suffer from various shortcomings, making their conclusions of greater productive efficiency only suggestive. Two of the three enterprise studies are based on samples of only 20 enterprises. Moreover, one of these, the Dollar study, omits intermediate inputs and uses data that cover a limited period of time before the industrial reforms were greatly expanded in 1984. With the exception of JRZ (forthcoming), which examines only two sectors, these studies suffer from their reliance on average products as a proxy for marginal products. Specifically, the use of average products to proxy marginal returns relies on two critical assumptions: (a) homogeneous production technologies, and (b) the use of average prices to proxy marginal prices. The wide range of industries represented in the enterprise samples suggests a wide variety of technologies, while the pervasiveness of the dual pricing system guarantees that for most state enterprises, significant differences exist between average and marginal prices.

3.4 This paper presents a more definitive analysis of productive efficiency than any of the previous studies. By investigating the convergence hypothesis within individual industry branches, the analysis relies less upon the assumption of a single, homogeneous technology across all industries. Furthermore, in order to control for enterprises operating under different price regimes -- enterprises operating wholly inside, partly inside and wholly outside the plan -- we also test the convergence hypothesis for categories of enterprises operating within homogeneous price regimes. Finally, no previous work using Chinese enterprise data attempts to investigate specific sources of changes in patterns of inter-enterprise factor returns. The present paper does so in two respects. First, it examines the respective contributions of gains in technical efficiency and allocative efficiency to greater productive efficiency. Second, the paper specifically investigates the role that changes in relative product prices have had on the dispersion of technical efficiency.

4. Measures of Efficient Production

4.1 One commonly used method of measuring the marginal revenue product (MRP) of factor i is to use the following expression:

$$MRP_{ij} = \partial Q_j / \partial X_{ij} = \alpha_{ij} (Q_j / X_{ij}) \quad (1)$$

where Q_j represents the gross value of industrial output in nominal terms in turn j ($j = 1, \dots, n$) and X_{ij} represents the factor input, where i = capital (K), labor (L or W), and materials (M). In this analysis, we use two measures of labor input -- a physical count of the number of workers (L) and a nominal measure of the total wage and bonus paid out to labor (W).⁹ Like labor's input, W, capital and materials are measured in nominal terms.¹⁰ The parameter α_{ij} represents the output elasticity of factor i . Returns are measured and compared across n separate firms.¹¹

4.2 The coefficient of variation, constructed as the ratio of the standard deviation to the mean of the individual MRPs, is an appropriate measure for the dispersion of factor returns among two or more firms. The coefficient of variation (CV) for factor i across n enterprises, is computed as:

$$CV_i = SD(MRP_{ij}) / \overline{MRP}_{ij} \quad (2)$$

A decline in the coefficient of variation over time indicates a convergence of returns across enterprises. A coefficient of variation of zero implies complete equalization of factor returns across all enterprises.

4.3 One important difference between the scheme set forth above and the methodology employed below is that Equation (1) measures the return to factor i in terms of its marginal

⁹ This measure of total wage and bonus payments omits fringe benefits, including housing and other in-kind services provided to employees. One method of estimating the value of the total compensation package, including these fringe benefits, is described in Jefferson and Xu, "The Impact of Reform on Socialist Enterprises in Transition."

¹⁰ Capital is measured as the net value of fixed assets (NVIO), constructed by cumulating a series of investment flows, each valued in current prices, and depreciating by the relevant rates of depreciation.

¹¹ Equation (1) is the measure used by JRZ (forthcoming) in their finding of a convergence of factor returns between state industry and collective industry.

revenue product. Below, by restricting our analysis to enterprises within single industries with similar technologies (i.e. similar α_j s), we use average products as proxies for marginal products. If the technologies of enterprises within the same industry are identical, then α_j in Equation (1), fixed for all j , can be factored out of the numerator (standard deviation) and denominator (mean) in the coefficient of variation. Once the α_j s have been canceled in the numerator and denominator, the coefficient of variation is simply the ratio of the standard deviation and mean of the average products of the sample enterprises.

4.4 For a sample of enterprises drawn from a wide range of industrial types, such as steel, textiles, apparel and food products, the factor output elasticities are unlikely to be uniform. Within one branch, however, the assumption of a uniform technology is more plausible, especially since we limit our sample to large and medium size enterprises. By investigating patterns of factor returns among large and medium enterprises within each of China's major industrial branches, we avoid the strong assumption, relied upon by previous studies, of a single homogeneous production technology for large and small firms in many branches of industry.

5. The Convergence of Factor Returns

5.1 The data we use consist of a sample of 226 of China's large and medium-sized industrial enterprises.¹² As such they allow for investigating the tendency for factor returns to converge in China's larger state-owned enterprises. The 226 enterprises are distributed over 10 industrial branches. The branch with the smallest number of enterprises, apparel, includes three enterprises, while our sample from the chemical industry includes 62 enterprises. Coefficients of variation are reported both for returns to labor in physical terms (Q/L) and in nominal terms (Q/W). For purposes of consistency with nominal measures of capital and material inputs, and because the nominal measure is more consistent with the economic logic of hiring labor up to the point which equalizes labor's marginal revenue product and wage, we limit our attention to the nominal measure of labor input.

¹² The data set was constructed by splicing data for large and medium-size enterprises in the CESRRI (Chinese Economic System Reform Research Institute) panel data set covering 1986-89 with the same enterprises for which data are reported in the Industrial Census of 1985 for 1980 and 1985 [*Zhongguo renmin gongheguo 1985 nian gongye pucha ziliao*, vol. 2 (a) and (b)]. The original set consisted of 661 enterprises from which enterprises missing observations for 1980, 1985, or 1989 were excluded. From the remaining 230 observations, one additional observation was omitted, because of the appearance of gross measurement error, and an additional three were omitted because they exceeded by 4 standard deviations the means of capital productivity (Q/K), labor productivity (Q/L, Q/W) or materials productivity (Q/M).

5.2 Before examining the data at the branch level, we note from Table 2 that within the full sample of 226 enterprises, the dispersion of returns to labor, capital and materials declines monotonically from 1980 to 1985 and from 1985 to 1989. The convergence is most pronounced for capital and least noticeable for materials. The full sample results also show that, at the beginning and end of the 1980s, the dispersion of returns to material inputs is considerably less than for labor and capital.

5.3 At the branch level, we also observe a general pattern of convergence of factor returns, although there are notable exceptions to this pattern. Among the 10 branches, from 1980-1989 returns to labor converge in five of the branches with the extent of convergence exceeding 25 percent in four of the branches while the degree of dispersion in the non-converging branches was trivial in all but two cases. Returns to capital converge in all but three branches, with the degree of convergence exceeding 25 percent in five branches while the degree of dispersion was of a similar magnitude in only one of the three non-converging branches. Finally, returns to material inputs converged in five of the 10 branches. Within each period, during 1980-85, convergence occurs for 20 of the 30 possible cases (capital, labor and materials within each branch); during 1985-89, the number falls to 17 of 30.

5.4 These changing patterns of factor returns by industrial branch reinforce earlier findings of convergence based on aggregate data, small enterprise samples or undifferentiated production technologies. Comparing rates of convergence, we see that returns to capital showed the greatest convergence, while reductions in the dispersion of labor and materials were more modest. Because returns to materials were the least dispersed at the beginning of the reform period, they offer less latitude for convergence than labor and capital whose returns were substantially more dispersed.

5.5 Differences in patterns of dispersion within single years and in patterns of convergence over time suggest important differences in market structures and reform emphasis. The relatively low dispersion of returns to materials in 1980 and throughout the 1980s may reflect the fact that, in China during the 1970s, a relatively small number of material inputs were allocated under the plan of the central government.¹³ In addition, during the 1980s, the practice of "gaojin-gaochu" - planners setting low (high) product prices and plan shares to correspond to low (high) input prices and plan shares--has tended to stabilize the ratio of output to input prices. The dispersion of returns to labor relative to capital and materials in 1989 reinforce the impression that, among China's large and medium-size state enterprises, labor markets remain among the least reformed

¹³ See Naughton (1990).

aspects of the industrial system. The slow convergence of returns to labor relative to capital may also reflect the relative intensity of reform of these two factor markets, with labor mobility and financial markets having become significantly more developed than labor markets.

5.6 Differences in the degree of dispersion of factor returns among industrial branches and the extent of convergence can potentially be explained by various factors including: (i) differences in price regimes which govern enterprises within a single branch and (ii) changes in relative product prices. These factors are investigated in Section 7.

6. Dispersion of Total Factor Productivity

6.1 Measures of the dispersion of single factor productivity shown in Table 2 indicate the extent to which factor returns have converged during the reform period. Earlier, we emphasized that factor returns may converge through two avenues. To see this, Figure 1 distinguishes between two kinds of efficiency. Firms located at A and B on Q_1^* , the frontier isoquant, are technically efficient, however, since they are off the expansion path OP, they are allocatively inefficient. Movement from A and B toward OP, would reduce the coefficients of variation that measure the dispersion of returns to factors X_1 and X_2 between these two firms.

6.2 What if the two firms are located at C and D, where C is technically efficient, but D is not? In this case, an increase in the relative efficiency of D, causing it to move toward the frontier isoquant, would lower the coefficients of variation for the dispersion of returns to X_1 and X_2 between C and D.

6.3 Both types of convergence, along the isoquant Q_1^* or along the expansion path OP, represent gains in efficient production. In the first case, owing to the curvature of the isoquant arising from diminishing returns, the same quantity of inputs could yield more output if they were operating at C. In the second case, the movement from D toward the frontier isoquant also contributes to an increase in overall industrial efficiency.

6.4 While both these changes will result in a convergence of factor returns and greater overall efficiency, they do not both imply a convergence of total factor productivity. If the initial condition is one of technical inefficiency represented by C and D, then a drift of D toward C will cause a convergence of TFP. By comparison, because, in principle, the measure of TFP is constant along any single isoquant, the movement of A and B toward C will not reduce the

coefficient of variation in TFP. That is, a convergence of TFP implies a convergence of factor returns; however, a convergence of factor returns need not result in a convergence of TFP.¹⁴

6.5 In order to evaluate the extent to which levels of technical efficiency among enterprises have become more equal, we construct measures of total factor productivity for 1980, 1985 and 1989 and evaluate their patterns of change over time. To do this, we assume a uniform Cobb-Douglas technology from which we develop the following expression:

$$\text{NTFP} = \exp[\ln Q - \alpha_k \ln K - \alpha_l \ln W - \alpha_m \ln M] \quad (3)$$

where α_k , α_l , and α_m are normalized factor output elasticities that sum to unity.¹⁵

6.6 Note that NTFP is constructed using outputs and labor and material inputs measured in current prices and the net value of fixed assets. No effort is made to deflate these inputs and outputs in order to achieve comparability of TFP measures over time and make inferences about the growth of total factor productivity during the period under study. Instead, we use current price values in order to allow for cross-section comparisons of enterprise TFP within each of the three years under review. To avoid confusing our measure of overall efficiency with conventional physical measures of TFP, we employ the term nominal total factor productivity (NTFP) to represent measures calculated from Equation (3) above.

6.7 The dispersion index of NTFP for the full sample, shown in the last column of Table 2, shows that for 8 of the 10 branches, the dispersion of NTFP declined over 1980-89. In 5 of these 8 branches, the decline is monotonic from 1980-1985 and 1985-1989. These results indicate that an important source of gains in efficient production was the tendency for the degree of technical efficiency among enterprises within the sample to become more uniform.

6.8 Another way of distinguishing between allocative and technical efficiency is to investigate the sign of the correlation coefficients pairing measures of single factor productivity. Firms that are allocatively inefficient, such as A and B, should reveal a negative correlation between returns

¹⁴ This would be the case unless there occurred an efficiency reversal—that is, technical inefficiency gives way to allocative inefficiency (i.e. D and C move to A and B) or allocative inefficiency is replaced by technical inefficiency (i.e. A and B migrate to C and D).

¹⁵ The weights, respectively 0.205, 0.120, and 0.675, are obtained from JRZ, who find that these estimates are stable over two cross-sections (1984 and 1987) of state-owned enterprise data aggregated to the urban level.

to factors X_1 and X_2 . Alternatively, unequal technical efficiency, such as shown by firms C and D, should result in a positive correlation between returns to X_1 and X_2 . That is, in firm D, returns to both factors are low, whereas in C, they are both high. If, over time, clusters of firms around A and B migrate toward point C, the correlation between returns to X_1 and X_2 should become less negative, while, the drift of a cluster around D toward a cluster around C, should cause the correlation between factor returns to become less positive.

6.9 Table 3 shows these correlation coefficients for the full sample for the years 1980, 1985 and 1989. These patterns indicate that during, the decade of the 1980s, labor and capital productivity have become only slightly more positively correlated, suggesting that gains in allocative efficiency have somewhat exceeded gains in the combined technical efficiency of capital and labor. Conversely, as between labor and materials, and capital and materials, increasingly negative correlations indicate that, relative to 1980, as a source of growing productive efficiency, gains in the combined efficiency of labor and materials and capital and materials have been large relative to gains in the efficient allocation of each of these sets of inputs.

7. Interpreting the Convergence of Factor Returns

7.1 In this section, we investigate two issues. First, we examine the implications for our analysis of differences between average and marginal prices resulting from the assignment of multiple prices for the same product within the same enterprise. Second, we investigate the extent to which changes in relative product prices account for the observed tendency for technical efficiency to converge.

Pricing Regime: Intuitively, changes in marginal revenue products across two or more sectors or enterprises result from two types of shifts. The first, affecting physical marginal products, includes changes in relative factor intensities, differential rates of productivity growth, and technological change which affects the magnitudes of the output elasticities. The second type of change affecting inter-sectoral or inter-enterprise factor returns leaves physical products unaffected but, by changing relative prices, affects marginal revenue products. This latter category includes both changes in relative product prices and changes in factor input prices across sectors or enterprises.¹⁶

¹⁶ See Jefferson (1991) for a framework which decomposes the sources of convergence of factor returns.

7.2 Firms that have identical technologies and factor proportions (i.e. identical marginal physical products) may have different marginal revenue products if they face different product and input prices. In Chinese industry, due to the dual pricing system, average and marginal prices will diverge, complicating the interpretation of marginal revenue product.

7.3 To test whether the patterns of convergence shown in Table 2 are sensitive to differential plan shares and price regimes, we split the sample into three parts based on their 1989 plan status: those selling 100 percent of their output within plan (74), those selling none of their output within plan (44), and those selling a portion of their output within plan (105). For the sample of firms selling all their product at plan price and the sample selling all their product at market price, average and marginal prices are likely to be similar, if not identical.

7.4 In Table 4, we report coefficients of variation for each of the three subsamples. The results, broken out by subsample, continue to show a pattern of convergence. With one exception out of nine possibilities, over 1980-1989 we observe a decline in the dispersion of returns to cash of the three factors within each of the three subsamples. In seven of the nine cases, factor returns converge during 1980-85 and again from 1985-89. All three of the subsamples display a monotonic decline in the dispersion of NTFP, indicating that a greater uniformity of technical efficiency accounted for some part of the observed convergence of factor returns.

7.5 Comparisons of the coefficients of variation and their patterns of decline are instructive. Compared with enterprises that operate fully within plan, those operating fully outside the plan generally reveal a greater convergence of factor returns and NTFP during 1980-89.¹⁷ Moreover, the dispersion of factor returns within each of the two subsamples in which enterprises sold a part or all of their output outside the plan had, by 1989, become substantially more uniform than within the sample of plan enterprises, suggesting the important impact that market forces have had in motivating efficient production. The fact that in 1989 the dispersion of NTFP in the non-plan sector fell from 61 percent to 45 percent that of the plan sector indicates that the market has served to discipline the least efficient enterprises, causing a more narrow dispersion of TFP.¹⁸

¹⁷ Among the 44 enterprises with all production standing outside the plan, 31 secure all their materials outside the plan. Within the sample, the average share of outside plan procurement of materials is 89 percent.

¹⁸ The smaller dispersion of factor returns and TFP within the outside plan sample in 1980, also suggests that at the outset of the reforms, this set of enterprises had a greater profit and market orientation than did those operating fully within plan later in 1989.

7.6 The case of a stable or slightly increasing dispersion of returns to material inputs in the mixed regime commands special interest. If prices and plan shares of outputs and material inputs are coordinated across enterprises, as intended by the policy of "gaojin-gaochu", we would expect greater uniformity of average and marginal returns relative to the case in which plan shares of outputs and inputs are uncoordinated. The correlation of 0.23 between output and material plan shares reveals only modest coordination of price regimes for inputs and outputs, within the subset of enterprises operating partly within and partly outside the plan. This condition may help to explain why, even as returns to capital and labor demonstrate convergence, we see no tendency for returns to materials to converge within this sample of mixed regime enterprises.

The Contribution of Relative Price Changes: To investigate the relationship between the convergence of enterprise efficiency and changes in enterprise product prices, we calculate three sets of correlation coefficients. These are:

$$1980-89: \text{corr}(\ln \text{NTFP}_{80}, \text{PD}_{80,89}) \quad (4a)$$

$$1980-85: \text{corr}(\ln \text{NTFP}_{80}, \text{PD}_{80,85}) \quad (4b)$$

$$1985-89: \text{corr}(\ln \text{NTFP}_{85}, \text{PD}_{85,89}) \quad (4c)$$

where the log of NTFP is for the years $t = 1980, 1985$ and 1989 and the price deflators (PD) are ex-factory price deflators for 1989 with a 1980 base price, 1985 with 1980 base and 1989 with 1985 base.¹⁹

7.7 The estimated correlation coefficients, shown in Table 5, can be interpreted in the following way. Coefficients with a negative sign indicate that enterprises with relatively low levels of NTFP at the beginning of the relevant period experienced higher than average increases in their product prices. In this case, changes in relative prices tended to contribute to a more equal dispersion of enterprise efficiency.²⁰ Conversely, a positive coefficient implies that enterprises with the highest initial levels of measured efficiency experienced relatively large increases in product prices, causing the dispersion of measured NTFP to become more pronounced.

7.8 For the full sample, the results show that for the entire period, 1980-89, as well as for each of the sub-periods, 1980-85 and 1985-89, changes in relative product prices generally

¹⁹ Obtained from JRZ (forthcoming), Table 4.

²⁰ Assuming limited instances of overshooting.

contributed to a declining dispersion of NTFP.²¹ This tendency of price reform to reduce the disparity in relative measures of NTFP also suggests that large disparities in measured enterprise efficiency and factor returns observed during the early stages of reform, in part, reflected differences in administered prices across enterprises.

7.9 There are two potential explanations of this tendency for price adjustments to equalize measured efficiency across enterprises. One is that the introduction and expansion of product markets has tended to rationalize prices, so that enterprises within the same branch face more homogeneous prices. The other potential explanation is that price adjustments reflect the behavior of bureaucrats seeking to help the least efficient enterprises by raising plan prices or reducing the share of plan production, thereby raising average prices.²²

7.10 In order to test whether the price adjustments that contributed to more uniform levels of measured efficiency reflect market forces or bureaucratic interventions, we focus our attention on the 44 enterprises which operated fully outside the plan in 1986. The question is whether we observe the same negative correlation between measured efficiency levels in 1985 and price adjustments during 1985-89 as found for the full sample. Since our subsample consists of enterprises operating outside the plan, opportunities for bureaucratic manipulation of prices and plan shares are limited; price adjustments should have largely affected changes in product mix and the impact of market forces on prices. Finding a negative correlation between $\ln \text{NTFP}_{85}$ and $\text{PD}_{85,89}$ of -0.274, somewhat larger in absolute value than the correlation for the full sample, we conclude that for the outside plan enterprise sample market forces have contributed to the convergence of technical efficiency. As price and enterprise reform has proceeded, causing prices to become more responsive to market conditions and enabling enterprises to substitute new products for old loss-making products, disparities in factor returns and enterprise efficiency have become less pronounced.

²¹ This is a partial analysis, since, as explained above, other factors, including changes in relative factor intensities, physical productivity and production technologies, were also motivating changes in the dispersion of factor returns and measured NTFP. Notwithstanding the impetus that relative price changes may have imparted to a particular enterprise for its NTFP to converge to the mean, any or all of these other factors may have overwhelmed this effect, resulting in more divergent levels of NTFP.

²² This second explanation, an appeal to Kornai's model of multiple instruments for softening the enterprise budget constraint, was suggested by one of the referees.

8. Conclusions

8.1 This paper formulates a strategy for measuring the progress of transition enterprises in achieving gains in efficient production, both allocative efficiency and technical efficiency. Applying the research strategy to Chinese industry yields evidence on behalf of the proposition that, during China's reform decade of the 1980s, returns to labor, capital and materials became more equal among large and medium-size enterprises within various industrial branches. While such a pattern of convergence can potentially arise from numerous sources, the consistency of the pattern suggests that even among large and medium-size enterprises within the core of China's system of state planning, greater market exposure and stronger profit-seeking behavior associated with the reform program are having the desired effect of motivating gains in efficient production. Despite the existence of market rigidities and the presence of bargaining, patronage, soft budget constraints and other phenomena that shield state-owned industrial enterprises from external pressure, profit-seeking behavior and market forces appear to exert regular and increasing pressure on Chinese industrial managers to economize on factor inputs.

8.2 Within this analysis, there has been no discussion of the economic significance of prices. A pattern of declining dispersion indexes is *prima facie* evidence of gains in efficient production. The extent to which these translate into efficiency gains in a general equilibrium sense remains open to question. If, as seems likely, the introduction of markets and exposure to foreign trade have caused arbitrary price differences among products and factors within the same industrial branches to narrow, and, simultaneously, factor intensities have been responsive to this rationalization of prices, then our measured gains in efficient production represent general equilibrium efficiency gains that would appear to be quite significant. This is an area that requires further investigation.

8.3 Economic transition in the socialist economies of Eastern Europe and the Soviet Union have motivated considerable debate over the appropriate speed of transition. Many economists argue that a rapid or "big bang" transition, involving the immediate privatization and marketization of state industry, is the only feasible way to succeed.

8.4 China's urban industrial sector is a model of gradual or partial reform. The enterprise contract responsible system and the dual track pricing system represent halfway solutions to problems of ownership and market reform. In this light, prior findings that TFP has accelerated in state industry to levels in the range of 2-3 percent per annum as compared with virtual stagnation during the pre-reform period and the finding in this paper concerning gains in efficient

production within the core of Chinese state industry provide strong evidence that China's program of gradual and partial reform has yielded substantial improvement in the economic performance of that country's industrial economy.

Table 1

Contributions to Annual Rates of Real Output Growth, 1980-88
(exponential growth rates in percent per annum)

	OUTPUT=	CAPITAL+	LABOR+	MATERIAL+	TFP
State	8.48	1.45	0.34	4.31	2.40
Collective	16.94	1.96	0.66	9.70	4.63

Source: JRZ (forthcoming)

Table 2

Coefficients of Variation (CV) for Factor Returns*
Large and Medium-Size SOEs

group	year	Q/L	Q/W	Q/K	Q/M	NTFP
full sample (226)	1980	0.91	0.86	1.04	0.29	0.32
	1985	0.85	0.80	0.82	0.26	0.26
	1989	0.76	0.73	0.64	0.25	0.21
industrial equipment (35)	1980	0.64	0.68	0.80	0.21	0.16
	1985	0.96	1.13	0.88	0.19	0.17
	1989	1.05	0.93	0.79	0.29	0.17
consumer durables (15)	1980	0.60	0.56	0.63	0.42	0.19
	1985	0.67	0.60	0.62	0.31	0.18
	1989	0.81	0.66	0.72	0.27	0.23
steel (23)	1980	0.81	0.76	1.02	0.16	0.30
	1985	0.72	0.72	0.89	0.22	0.19
	1989	0.61	0.53	0.54	0.21	0.13
non-ferrous (4)	1980	0.68	0.53	1.23	0.27	0.22
	1985	0.49	0.40	1.02	0.21	0.16
	1989	0.43	0.39	0.74	0.17	0.09
textiles (24)	1980	1.04	0.97	0.63	0.19	0.17
	1985	0.62	0.62	0.35	0.17	0.10
	1989	0.69	0.68	0.36	0.16	0.12
apparel (3)	1980	0.19	0.11	0.64	0.03	0.12
	1985	0.11	0.14	0.33	0.06	0.06
	1989	0.30	0.15	0.15	0.09	0.10
chemicals (62)	1980	0.73	0.67	0.91	0.15	0.27
	1985	0.60	0.51	0.56	0.15	0.22
	1989	0.40	0.35	0.45	0.15	0.14
food products (20)	1980	0.76	0.76	0.91	0.34	0.41
	1985	0.84	0.80	1.04	0.31	0.43
	1989	0.75	0.76	0.73	0.33	0.35
building materials (13)	1980	0.44	0.42	0.35	0.16	0.17
	1985	0.41	0.31	0.50	0.13	0.16
	1989	0.45	0.39	0.56	0.18	0.15
other (27)	1980	1.00	0.98	0.58	0.35	0.29
	1985	1.10	0.96	0.62	0.32	0.27
	1989	0.97	1.00	0.61	0.19	0.21

* $CV = SD(Z_i) / \bar{Z}_i$, $i = Q/L, Q/W, Q/K, Q/M$ and NTFP.

Table 3**Productivity Correlations**

	$(Q/W)_j, (Q/K)_j$	$(Q/W)_j, (Q/M)_j$	$(Q/K)_j, (Q/M)_j$
1980	0.645	0.031	-0.051
1985	0.720	-0.220	-0.130
1989	0.661	-0.149	-0.321

$j = 1 \dots 226$

Table 4**Patterns of Convergence within Subsamples
(coefficients of variation)**

	Q/W	Q/K	Q/M	NTFP
A. Sales 100 percent within plan (74):				
1980	0.883	0.998	0.314	0.363
1985	0.832	0.904	0.307	0.332
1989	0.749	0.701	0.294	0.271
B. Sales partially within plan (105):				
1980	0.800	1.044	0.206	0.265
1985	0.737	0.693	0.201	0.194
1989	0.662	0.574	0.217	0.153
C. No within plan sales (44):				
1980	0.834	0.800	0.272	0.221
1985	0.506	0.614	0.206	0.144
1989	0.452	0.490	0.220	0.123

Table 5**Correlations Between NTFP and Price Changes**

group	1980-89	1980-85	1985-89
full sample (226)	-0.142	-0.139	-0.130
indust. equip (35)	-0.145	-0.267	-0.158
consumer durable (15)	-0.076	-0.225	-0.195
steel (23)	-0.017	-0.067	-0.048
non-ferrous (4)	-0.571	-0.769	0.169
textile (24)	-0.314	-0.484	0.109
apparel (3)	-0.031	-0.643	-0.997
chemical (62)	-0.392	-0.343	-0.349
food products (20)	-0.239	0.116	-0.352
building mat'ls (13)	-0.306	-0.176	-0.434
other (27)	-0.216	-0.321	-0.202

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